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ABSTRACT

Papers on book and document conservation and restoration, which were presented at the 1983 International Federation of Library Associations (IFLA) conference, include: (1) "The Problems of Conservation of Valuable Library Possessions," in which Karl Jackel (West Germany) discusses problems in obtaining restoration materials, storage facilities, craft techniques, and guidelines for preservation and restoration of various types of library materials; (2) "Mass Deacidification of Paper," in which Peter G. Sparks (United States) describes the causes of and known solutions for brittle paper, including the manufacture of alkaline paper and the mass deacidification process as used in the Library of Congress and other United States archives/libraries; (3) "On the Possibilities for Mechanisation in the Restoring Profession," a description by Wolfgang Wachter (East Germany) of the development of mechanized work processes in the restoration workshop of the German Library in Leipzig, including wet treatment of paper and stabilization of wood-pulp paper by the splitting method; (4) "The Treatment of Paper for the Conservation of Rare and Precious Books," in which Anthony G. Cains (Ireland) describes the cleaning, buffering, and strengthening of paper by immersing it in or floating it on a processing solution as well as brush application of methyl magnesium carbonate, use of a spray gun, fixing, and book repair. (ESR)

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IFLA 1983

IFLA GENERAL CONFERENCE MUNICH 1983
Division: Management and Technologie
Section : Conservation

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The problems of conservation of valuable library possessions

by

Karl Jäckel
Werkstattleiter (a.D.)
Institut fur Buchrestaurierung
an der Bayerischen Staatsbibliothek
Munich, West Germany

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Even before the actual conservation work on the binding begins, the first theoretical problems must be faced. Every effort is made to retain all existing, original material in the book.

In general this is perfectly possible, but whether it is always done is another question. The conservation of books must be approached in a different way to the conservation of museum pieces.

The aim of restoring a book is that after completion of the work the book should once again be in a condition to be handled and used. This need not be the case with a museum piece.

The need to be able to use a book again means that one must be able to handle all moving parts of the book with ease, namely the hinges on the binding, the stitching, the cords and the spine.

It is in these functional parts of a book that the majority of damage occurs, and renovation can be a thoroughly good thing although it must be borne in mind that the outward appearance of the book or manuscript should not be impaired. Basically however it is impossible to make generalizations: each case is different and must be treated on its merits.

Obtaining materials

Obtaining materials can be a genuine problem.

Modern finished leathers are not suitable for the purposes of restoration because they are too strongly grained and rarely correspond to the exact colour of the old book. They are too heavily dependent on current colour trends.

For this reason the IBR decided from the beginning to buy leather uncoloured and to colour it itself.

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Tanneries, which undertook the production of unusual types of leather, have for various reasons moved away from this type of production. Specially prepared leather can only be obtained by ordering large amounts of the same type. In practice however widely varying types of leather and tanning are needed.

Wood for book covers is best bought by the metre and in different grades. The exact cut for any piece of work can then be made in your own workshop. In the long run it would be too expensive and time-consuming to order binding covers from the joiner as and when they are needed.

Hand-made papers are rare today and have become correspondingly expensive. From a purely optical point of view they cannot be replaced by modern papers. The price per sheet drops several per cent if large amounts are purchased.

Coloured papers which match an old book in colour and design are not always available. In producing it oneself it is wise to produce more than is immediately needed.

These few examples already show that it is essential today to have a store.

Storage facilities

The keeping of a store brings with it many advantages, but also a few problems. It is of course an advantage to have all the necessary materials at hand. It is important that woods and boards should be allowed to dry out over a long period.

The greatest problem is the increased need for space. A room that can be locked is obviously ideal. There is no absolute need for windows, but the climate in the room must be controlled and regulated (Not above 20°C, 40-60% relative humidity).

A record must be kept of the receipt and use of materials. This obviously shortens the amount of time left for pure conservation work.

Craft techniques

The on-site colouring of leather or production of coloured papers were common procedures within the book bindery in the last century.

Stitching onto genuine cording is a costly activity. In the nineteenth century the procedure was greatly simplified, and today string and twine are used almost exclusively.

Attempts to carry this work out on a machine did not succeed until the nineteen-thirties.

This development went a step further after the second world war. The backs of the individual quires were trimmed off and glued with a modern synthetic resin adhesive. The process of stitching with binding thread was thus completely eliminated.

Initial enthusiasm for this supposed breakthrough soon died down because its durability had been overestimated, and further repairs dictate renewed cutting and glueing of part of the spine.

For conservation work neither a stitching machine nor any of the new, threadless binding methods can be used. In both cases, the ensuing damage between the body of an old book and the binding could never be rectified.

For the curator a knowledge of the old working methods which have proved themselves over the centuries is important. This is not to say that a negative attitude should be taken to new ideas; however they should be put into practice only after the closest analysis.

Anything special, anything that departs from the norm is of course always of great interest.

Metal covers were first shaped in the style of the times, then the individual metal parts were nailed onto the binding covers. In the case of small format books the metal cover was fashioned in one piece and its edges tapped around the binding covers.

Occasional attempts to produce the binding purely in metal or another material did not always succeed because too little account was taken of the movement of the spine during use of the book.

A knowledge of metalworking is indispensable for binding restorers. They must be able to repair old clasps and fashion new ones. They must be able to saw out shapes from tin, prepare them and fit them. Knowledge of moulding, of hard-soldering or even engraving of the simplest kind is of great usefulness in their work.

Wood and horn bindings have a flexible cover and a stiff spine. They are stitched with an extra thick, decorative thread. This thick thread causes a marked lifting of the spine. Harmonising the height of the spine, the strength of the thread and the ensuing lifting can cause difficulties in restoration.

Bag binding is admittedly extremely rare, and from a technical point of view there are few problems in the restoration process.

Greek manuscripts are bound in a style that affords little comparison with any other books produced in the west. The wooden covers are stitched to the body of the book, the head-cap overlaps several centimetres onto the wooden covers, and the clasps and clasp strings have their own typical shape.

Examples of work

In actual practical work questions will always be cropping up to which answers must immediately be found. For instance, what about damaged stitching? Should it be repaired or renewed? Fresh stitching can on the one hand mean a lot of work because the whole book must first be taken apart. On the other hand the existence of the item concerned is guaranteed for many years.

Wooden covers are very often highly acceptable for a high use book and can be re-used. Problems with insects only occur where a book or a row of books are left to stand untouched on the shelf for a long period of time.

Renewal of a leather-surfaced wooden cover can present enormous difficulties, depending on the condition and design of the cover.

A thorough softening of the old leather with water cannot be avoided. The transfer of the leather onto the new cover must be made without any pressure, so as to avoid damaging the design.

With a half leather cover new wood can give a most disturbing effect because of its light colour. If it is to be coloured afterwards, too little is always better than too much.

Gold pressing and blind embossing on a binding with cardboard covers usually presses deep into the cardboard. The old couched cardboards in use until the nineteeneth century were softer than the subsequent machine produced types.

When an old cardboard needs renewal there is always the problem of how best to retain the typically deep impression. It has proved a success to just split the old cover and to peel or grind off the upper side with the cover, until the deepest impression appears. The edges are then sharpened or ground as far as the leather. The old cover can thus be saved for further treatment.

Clasps for a parchment book should be repaired or replaced in every case. Parchment always has a tendency to warp or lose its shape, and only clasps can prevent this.

Whether gold pressing and blind embossing should be replaced differs from one case to another. Whilst it is sometimes done, it is certainly not the rule.

Globes are also found in the collections of many libraries. The external form was the work of craftsmen of different professions. The bookbinder fashioned the sphere using a thin cardboard. The wood-turner was responsible for the wooden stand, the beltmaker or fitter for fixtures and anything that moved on the globe. Production of the segments was the work of the copperplate engraver.

Damage to globes can occur in the most widely differing places. In the conservation process one must produce some of the aids to repair oneself. Amongst other things, a cushioned cardboard ring has proved valuable, upon which the sensitive sphere can be rested whilst work is being carried out.

The bindings of Ethiopian-Coptic manuscripts are generally very simply made. Care must be taken with the stitching; as in the case of Greek manuscripts, the stitching thread ties together the book and its covers.

Manuscripts from Arabic countries are bound much less robustly than in the West. Instead of wooden covers cardboard was used, and neither clasps not catches were common.

Smaller formats were bound with cardboard or even half leather and covered with coloured paper. Coloured papers produced on a viscous bed of carrageen are typical. They can no longer be purchased today and must be home-produced according to need.

On books bound entirely with leather, decorative techniques may be found which were unusual in the West. Ornamental cutting work in leather lined with coloured silks, mounted on the binding or inside cover, are hardly ever found in the West.

Persian varnished bindings depart from every norm. Instead of a leather or paper cover, the binding covers are decorated with varnish artwork. The retoration of arabic bindings demands the most extreme concentration and intuition.

Oriental papers are more sensitive to water than western papers because the paper fibres and the sizing are different to those found in the West. Writing on them with an **iron gallotanate** ink would hardly be possible; the liquidity demands instead a colour tempered to this purpose. The script and artwork in the book are usually extremely sensitive to humidity.

The bindings of Japanese and Chinese manuscripts and printed works are light and flexible. A folder or wooden casing is often used to replace them. The chief difficulties lie more in the area of paper restoration. The IBR has used it's leaf-casting instrument to good effort here.

In India and Ceylon, as well as in countries bordering on the East Indies, palm leaves were used to write on. Palm leaves are long and narrow and their shape influenced paper manuscripts from these parts as far afield as Tibet.

The bindings for palm leaf and paper manuscripts consist of two wooden strips which were laid at the beginning and end of the manuscript and tied to it.

The binding covers may be very simple, but they may also be often painted, decorated with brightly-coloured glass, or even carved and gilded most exquisitely.

Works from the Indonesian islands etched or engraved onto bast, bone or metal plate are of course rarities, but extremely interesting for this very reason.

Librarians and Restorers

The help of the Librarian in conservation work is desirable. The Librarian should, if possible, give precise details of his ideas and wishes, whilst the curator must harness them to the possibilities open to him.

Identification marks on a book such as old signatures, details of ownership etc, are often faded or be be found in obscure places. They can easily be overlooked and hidden by subsequent conservation work.

If the curator is made aware of this, he is being simultaneously educated and given the means to recognise more easily such features in the future.

What should be done with inscribed fragments that have strengthened stitching in the body of the book or pasted over end-papers must be decided by the Librarian anyway.

Dangers for books today

Today too there are a number of sources of danger for books.

The same items are used all too often at exhibitions and displays. They are thus exposed to repeated wear and tear.

At exhibitions books are put in a given place and left there for weeks or months at a stretch. At external exhibitions there is the added danger that they may be handled by people who do not always have the necessary respect for a book.

Lighting conditions in the exhibition room may change dramatically in the course of a day. They must be monitored and altered where necessary.

In reproduction work the book is generally taken apart and photographed. The heat of the photography lamps can adversely affect parchment and miniatures.

In addition, for security reasons the single pages are usually brought one after another to the reproduction establishment, reproduced there and then transported back to the library. The original will of course undergo less stress in future if there is an in-house reproduction facility.

In photographing or photocopying a single page from a bound volume, the book must be opened so wide that the old, hardened leather cording or the hinges are all too easily broken.

All these sources of danger are very well known. They can scarely be eliminated, however, since in this day and age it is not possible to reverse the course of these public services at a stroke.

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Division: Management and Technology

Section: Conservation Section/Standing Committee

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Mass Deacidification of Paper

by

Peter G. Sparks

Director for Preservation

Library of Congress

Washington, D.C. 20540

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MASS DEACIDIFICATION OF PAPER

IFLA CONFERENCE, AUGUST 26, 1983

The objective of my talk this morning is to present some key facts about a technology that will have a significant impact on library preservation and service. Deacidification of paper has been around as an idea for about a decade. Single page deacidification is a proven process while mass treatment is on the verge of availability.

The principles of paper making have not changed since its invention in China nearly 2,000 years ago. The basic ingredient of paper is cellulose fiber which for centuries was obtained from old rags of linen, cotten clothing, and other plant sources. Cellulosic fibers can be separated and processed in water, and dried, to form a tightly woven paper mesh. In the middle of the 19th century the demand for paper had surpassed the supply of rags and hence the gradual conversion to wood pulp papers began. The crushing of the fibers with the mortar and pestle to make pulp became highly automated with the advent of continuous paper making equipment and in the case of better grade book papers it became a chemical process. The great speed at which modern papers can be made was achieved at the expense of paper permanence. It is the modern chemistry of pulp and paper production that has introduced the acids that cause paper deterioration. Acid producing materials enter the paper in chlorine bleaching and,

more seriously, with the introduction of sizing essential to modern printing papers. Earlier paper was sized by dipping in gelatin or natural glue-like mixtures. Modern papers use rosin that is precipitated with a chemical known as alum which is the principle cause of acidic paper.

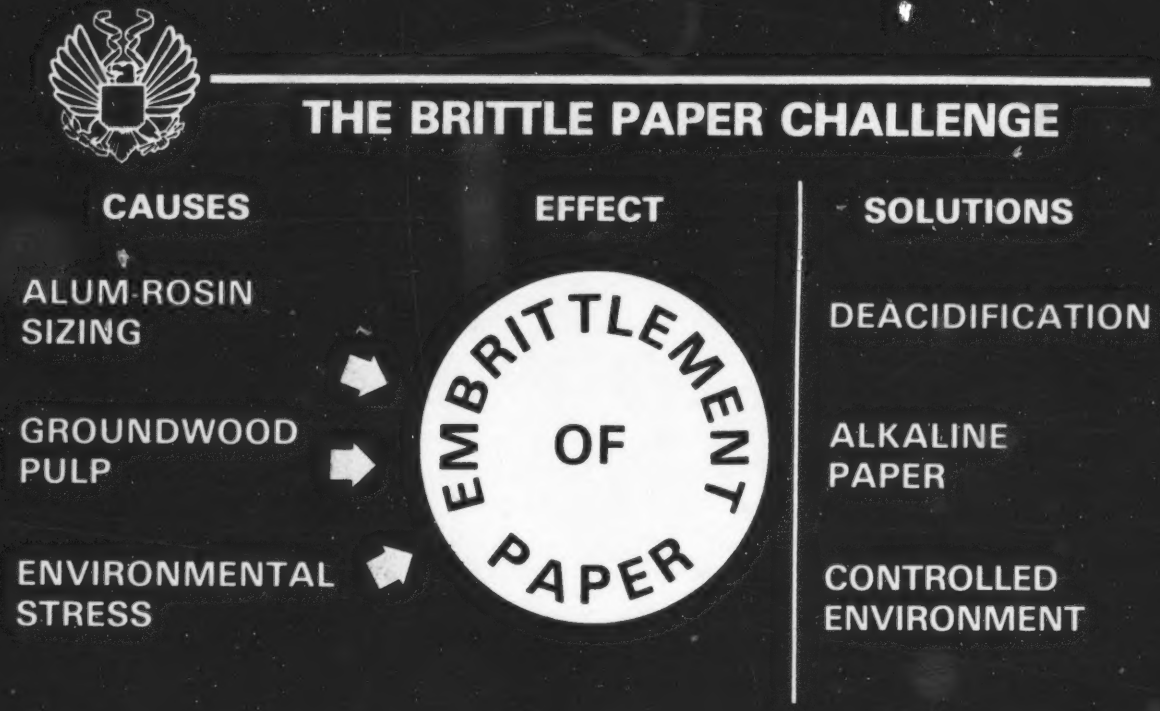
The alum/rosin sizing system is considered essential to modern printing papers in order to make fibers water resistant and prevent printing ink from feathering. Moreover, alum serves as a retaining agent to help clay fillers adhere to the fibers during paper forming on the screen. The papermaker's natural reluctance to abandon this useful process, which helped meet the ever growing need for inexpensive printing papers, needs to be understood in relation to the very modest market demand for permanent papers.

The brittle paper challenge is summarized in the following figure. Causes are shown on the left and known solutions on the right. The causes are well understood with the primary culprit identified as alum-rosin sizing. The solutions yield papers whose lifetimes can be measured in centuries rather than decades. Environmental controls are important because the two solutions depend on good conditions for maximum lifetime benefit.

Before discussing deacidification, I would like to say something about another important solution--the manufacture of alkaline paper. These papers are made with non acidic sizing systems, have a built-in $CaCO_3$ alkaline reserve, and use only purified wood pulp.

Dr. Edwin Sudemeister, who worked for the S. D. Warren Paper Company at the turn of the century, first identified alum as a primary cause of paper deterioration. In addition, he found that calcium carbonate could be used as a filler to give paper excellent protection against

THE BRITTLE PAPER CHALLENGE



continuing acid reactions from any source. Dr. Sudemeister has been referred to as the father of modern paper chemistry and his papers remain in pristine condition to this day. Unfortunately, his discovery drew little notice and had only a small effect on paper making in his time.

The S. D. Warren Company did, however, produce an unsized calcium carbonate filled sheet in the early 1900s. This paper was adaptable to letter press printing and could be made into books. Presently, paper companies such as S. D. Warren, P. H. Glatfelter and others had moved into production of modest amounts of alkaline paper available for printing purposes.

Now, some simple chemistry about why paper becomes brittle and how the deacidification agent stops this process.

The embrittlement process can be best understood by looking at paper and its chemical characteristics at the molecular level. If we start with a sheet of paper and look at the fibers at higher and higher magnifications and continue this process into the world of molecular dimensions we would get to a point where we could see the cellulose chains that are made up of connected rings having specific chemical groups attached to them. This chain structure can be idealized to a ball stick model so the cellulose can be viewed as a collection of beads, held together by links in a long chain. It is important to keep in mind that cellulose is a natural polymer made up of many similar elements linked together into this long chain and has dimensions thousands of times larger than small molecules. It is this long chain characteristic of cellulose that contributes directly to the paper fibers strength. With this in mind, let us leave our mental image of the cellulose molecule and talk about alum sizing.

Alum is a common name for a compound used in the paper industry known as aluminum sulfate or sometime referred to as potassium aluminum sulfate. Under the influence of high humidity and warm temperatures alum breaks up into different products by a reaction called hydrolysis. Depending on the type of alum used the products are sulfuric acid and one or two bases. The acid generated from the hydrolysis of alum attacks the cellulose molecule and changes the nature of the various pendant chemical groups on the cellulose chain in a complex series of reactions which eventually lead to the breaking of the chain structure. This chain cutting process yields a paper that is weak and embrittled. There is a direct relationship between the size of the cellulose molecule and the strength of the paper fiber.

The application of a deacidification agent to the paper inhibits this chain breaking process. These agents are usually chemical compounds called bicarbonates or carbonates which react directly with the free acid in the paper, producing through a series of reactions the harmless salt of the acid, carbon dioxide gas and water. Thus, a simple chemical reaction between the deacidification agent and the free acid in the paper prevents the acid from attacking and cutting the cellulose chain. Incidentally, deacidification of paper that is already embrittled appears to accomplish very little. Once the cellulose chains are broken deacidification cannot put them back together again. Deacidification should be applied to papers that still have strength in order to achieve any significant improvement in permanence.

Now, I would like to cover some basic ideas about deacidification, deal briefly with single page treatment and then move on to mass treatment. All successful deacidification processes whether they are single sheet or

mass techniques have some fundamental similarities. In all processes the agent is first brought into intimate contact with the paper material. In the single sheet processes the agent is dissolved in a liquid and brought into contact with the paper in this vehicle. In the mass processes one sees both liquid and gas phase contact.

Secondly, the deacidification agent chemically neutralizes all the existing free acid in the paper.

Thirdly, an alkaline reserve is generated or left in the paper,

and, fourth, all liquids or reaction by-products are removed from the paper before it is returned to circulation.

This leads to eight criteria for judging a good deacidification process:

1st. The agent must be uniformly distributed through the entire sheet of paper.

2nd. The agent must raise the pH of the paper to between 7 and 8.5. The pH value is a relative measure of the acidity or alkalinity. Values below 7 are acidic, 7 is neutral, and above 7 alkaline.

3rd. The process must leave an alkaline reserve in the paper between 2% and 3% by weight to chemically neutralize any further acidic products.

4th. The agent must penetrate the paper in a reasonable length of time so that the process is time efficient.

5th. The treatment must be permanent, that is, the alkaline reserve should not go away with time and allow the pH of the paper to return to the acidic side.

6th. The treatment should impart neither odor nor have any toxicological risk to people. The latter is extremely important when you consider the implications of putting large numbers of deacidified books in libraries.

7th. The treatment should have minimum side effects on the book, i.e., it should not have any noticeable effect on binding material such as covers, adhesives, leathers, sewing thread, etc. and it should not have a measurable effect on colored print inks.

8th. The process should be able to do all of the above at a reasonable cost per book.

There are a number of deacidification processes that have been used and experimented with in the last 20 years and the more important ones are shown in the next figure. The first four processes shown have been used for single page deacidification, while the last two processes have been used in mass deacidification. The chemistry developed by Richard Smith has been used in both. The two Barrow processes received considerable use in the early days for single sheet work. More recently the Library of Congress process and the Smith's process have become popular for single sheet treatment.

Single page deacidification is usually applied to rare and important items and done by, or under, the guidance of a trained conservator. The technique cannot be applied efficiently to thousands of items at once although with similar materials one can develop limited

EXISTING DEACIDIFICATION TECHNIQUES

MAGNESIUM BICARBONATE **BARROW**	CALCIUM HYDROXIDE/ CALCIUM CARBONATE **BARROW**
CYCLOHEXYLAMINE CARBONATE **LANGWELL**	METHYL MAGNESIUM CARBONATE/ MAGNESIUM CARBONATE **LIBRARY OF CONGRESS**
MAGNESIUM METHOXIDE/ MAGNESIUM CARBONATE **SMITH**	
MORPHOLINE **BARROW LAB**	DIETHYL ZINC/ZINC CARBONATE **LIBRARY OF CONGRESS**

production techniques. The preservation opportunities available in single sheet deacidification are as follows:

— Several good processes available.

— Requires trained conservator/technician.

— Slow production.

— Used with rare materials.

— High unit cost.

The attempt to find techniques for treating great numbers of items at the same time has led to much research and development in the last 10 years. The objective of this research has been to develop a chemically sound process that is cost effective and which can treat hundreds of thousands of items in any given year. This effort resulted in three processes coming under consideration. Dr. Richard Smith has developed a nonaqueous liquid process using magnesium methoxide. The Barrow Laboratory, during its last years, developed a process using morpholine and, the Library of Congress, after an exhaustive research program, settled on a gas phase process using diethyl zinc. The Smith processes, and the Library of Congress diethyl zinc process, have emerged in the last few years as having potential.

The Library of Congress has chosen a gas phase process using diethyl zinc (DEZ for short) which has been successfully demonstrated at the lab bench, pilot plant scale and at the large scale plant level with about 6,600 books treated.

We have been working with the NASA's Goddard Space Flight Center for the past two years to buy the engineering required to scale up, using a

chamber that will hold 5,000 books and to demonstrate the process at this level. The first 5,000 book test was accomplished on October 15, 1982. Additional trials and experimentation leading to an optimum plant design are underway.

Because of the reactive properties of DEZ it cannot be exposed directly to water or oxygen. Thus the treatment must be carried out in a closed chamber so that the books and the DEZ gas can be brought together in an environment free of water and oxygen. Diethyl zinc as a material possesses properties that set its deacidification mechanism apart from others.

The molecule itself is very small, 10 angstroms from end-to-end which mean you could put approximately 2 million of them across the head of a pin. DEZ moves easily between the pages of the book and diffuses into the paper fibers coming into intimate molecular contact with the cellulose chains. It is possible that diethyl zinc molecule may bond directly to the cellulose chain or chemiadsorb on the fiber's surface. At the end of the process the alkaline reserve compound zinc oxide or zinc carbonate is generated. It appears that one of the interesting results of this molecular level generation of the alkaline reserve is a uniform distribution of small particles of zinc carbonate and/or zinc oxide throughout the fiber.

The diethyl zinc process is carried out in four stages. First the residual water in the book is removed so that the heat from the reaction of the DEZ with any excess water is minimized. Once this is completed, in about one day, DEZ is introduced into the chamber as a gas and left to permeate the paper and neutralize excess acid for a period of 3 to 4 days. At the end of the permeation process the excess DEZ is removed and

reclaimed. Finally in the passivation stage the alkaline reserve compound is formed. Some water is re-absorbed into the paper at this stage and the paper reaches its final equilibrium water content in a few weeks. We are packing books in small stackable milk crates in our Binding Office and are marking our treated books with a simple stamp identifying the DEZ process and the year treated.

We enlisted feedback in this test from six other libraries: New York Public Library, Yale University Library, Northeast Document Conservation Center, National Archives and Records Service, Columbia University Library, Stanford University Library. A battery of additional tests have been made on materials in the 5,000 book run and results indicate good treatment of the text block. Several engineering challenges with "DEZ" distribution in the chamber and "DEZ" injection have been solved. Mass deacidification has some significant preservation opportunities.

— Large numbers treated.

— Permanent effect.

— Smith process available 1982.

— DEZ process available 1984

— DEZ process inhibits biological growth.

— Low unit cost.

The Library of Congress is developing plans for implementing the diethyl zinc process on a larger scale. Our current best case plan is an operational 15,000 - 20,000 book plant by late 1985.

In summary let me leave you with some encouraging words about deacidification as a promising approach to keeping the "book" available in libraries and preventing costly microfilming of brittle materials. The

brittle paper challenge in front of us has been clearly defined. We know why paper becomes brittle and have identified several solutions to prevent this from happening. Manufacture of alkaline paper and the mass deacidification of library materials to make them alkaline appear to be the promising approaches to extend the permanence of new and stronger papers.

The combination of deacidification technologies and production of and printing of library materials on alkaline paper can provide the team work to solve this important library preservation challenge.

It is clear that the benefits of mass deacidification can and will play a key role in the preservation of library material that must be kept in original format. The future looks encouraging for this preservation technology because we are in the home stretch of making it available for production treatment. With continued engineering and process development, two acceptable processes will be available soon to deal with the large number of books projected to be treated. The library field will be in a position of choosing the processes they feel to be useful for deacidifying their own collections.

Research libraries will need to plan to take advantage of mass deacidification and books printed on alkaline paper so that we can solve this important worldwide challenge by the end of this century.

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On the Possibilities for mechanisation in the restoring profession

Wolfgang Wächter

Deutsche Bücherei

Leipzig, DDR

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On the possibilities for mechanisation in the restoring profession

- Wolfgang Wächter.

The necessity for the mechanisation of restoring routines arises from various aspects which are based on organizational, economic and technical structures and the like, as well as the social and institutional areas.

Unburdened by any prejudices or preconceptions amongst librarians, tendencies for development stand out in both restoring and conservation areas which can, quite justifiably, be termed "mechanisation".

Starting from H. Bansa's theses on conservation problems in libraries, which states in thesis 5 that: "It is possible in every case to strengthen paper which has been damaged by aging."

Thesis 7 sets forth the consequences of thesis 5: "All methods of treating finished, handwritten or printed sheets on paper in book form in order to improve its ability to withstand aging and to reestablish lost strength, or for transfering information are costly in terms of time and equipment.

These very general statements characterize the present state of development, depict the present situation and show the limits of traditional restoration procedures.

The great gap between the possibilities for restoring on the one hand and the high cost of realising these possibilities characterize the developmental tendencies for restoring.

The drive to mechanize restoring work procedures can therefore be related to:

1. The established level of knowledge.
2. The material condition of a substantial part of library collections.
3. The very vital optimization of the ratio between cost and benefit.
4. The recognition that optimum quality can only be attained through the mechanisation of the work process.

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We have been aware of mechanised work procedures in the field of restoring for quite a while now. I will only draw attention to the historical development of leaf casting. The first attempts with the most simple equipment such as spoons and flasks contrast with what is today a mass of apparatus or completely mechanised systems such as the Soviet Rom II- Rom III. We know about the development and modus operandi of the Spanish Vinyector with its ability for wet treatment and the leaf casting process.
And from the French national library comes the development of the "Reliant' process a profitable modified variation of lamination.
Of course we all heard about the use of great technical complexes developed for space travel for the mass deacidification of books in the USA.
All the aforementioned examples can be understood as solutions for individual problems in restoration. These necessary developments have up to now been unsuited for satisfying the bulk of requirements in mechanised restoration.
The formulation "bulk of requirements" backs a change whose speed is defined by the scientific level of knowledge and the change in aesthetic categories and technical possibilities on which its depends.
Considering this we will refer to the development of mechanised work processes in the restoration workshop of the German Library in Leipzig.
In our restoration workshop we have made a great effort in past years to achieve the development of extensive mechanised restoration procedures on the basis of planned research areas. The first result of his work was in 1979 when a facility for the wet treatment of paper began to operate. The concept of this wet treatment plant was achieved after taking into consideration all the significant and new results from cellulose research, the aging process of paper and modern chemical engineering, as a result of which the technical conversion was achieved at as little structural expense as possible. This aim was enhanced by the necessity to create a tool for the restorer which besides having a rational system of operation could also take into consideration individual variations in the wet process as well as result in an improvement of the working conditions.
As a succession of rinses, deadification and buffering as well as the basic conservation, the wet process presents itself as a genuine mass problem, particularly for extensively badly damaged books and a high expenditure of time and energy is indispensable. The quality of the wet treatment decides to a considerable degree the quality and life of the treated books and papers.
The traditional manual wet treatment for paper contains a few serious weaknesses in its method. Only in exceptionally rare cases can for example a large number of single sheets be handled under exactly the same conditions.
The amount of time necessary in soaking and transport through the solutions results in inevitable variations in the reaction time for individual sheets or sets of sheets.

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The necessity for an exact rinse and the control of rinsing procedures are requirements which in practice are inevitably not solved to an optimum degree. Deacidification and the creation of an alkali reserve is generally carried out empirically and without constant controls or exact instructions for the quantities. The frequently fragile condition of the paper increases the difficulty in handling and makes special precautions necessary whose application means a further increase in cost. The lengthy contact of the restorer himself with the solutions and chemicals in certain circumstances, can be reduced through the use of barrier creams, but despite this it presents a considerable burden. All of the qualitative disadvantages of the manual wet treatment could be reduced in the workshop through increased use of equipment. However, the quantitative results cannot overcome the barriers set by human potential. Seen in this light the mechanized wet treatment process solves both the qualitative and the quantitative problems and reduces the total cost for an effective and exact wet treatment.
The sheets to be processed are placed in a transport and security system after being dry-cleansed. Two types of this standardized system exist whose application is dictated by the shape of the original sheets.

Type I

For large sheets such as newspapers and the like, a system of support materials, made from perforated sheets of PVC, is best suited. These alternate with sheets of polyamide gauze to enclose the original sheets. 80-100 sheets can be secured and stacked upright simultaneously in one of the transport containers of the installation. The fine polyamide gauze holds the large sheets securely in a vertical position and ensures excellent penetration for the entire batch by chemicals with varied degrees of solubility. The support and securing materials are able to withstand changes in temperature, are easy to handle and durable.

Type II

For smaller and medium-sized sheets we use numerous filter rolls. These rolls comprise the roller itself, which is made from a hard PVC material and two filter-belts, which lie one on top of the other. The outside, large-grid filter, serves to maintain the necessary spacing of the sheets in the roll and is, at the sme time, the conduit for the various solutions. The second fine-grid filter lies on top of the first coarser one and the sheets of paper are arranged on this.

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The roller is fastened in a simple winding device, and after arranging the sheets, the filter belts are wound onto the roller body. In the resulting column, which in our case reaches a height of 40 cm and has a diameter of 16 cm, any number of sheets, according to size, can be housed (the average is 50 sheets), for which the condition or degree of damage has on the whole, no meaning at all. Two catches secure the column, which is then removed from the winding device and placed in the transport container of the wet treatment installation.

The transport container can take 8 rolls, that is 400 sheets altogether. In the rolls the individual sheets are immovably fixed. During the whole of the wet treatment process they undergo no further mechanical strain whatsoever. The filter materials guarantee a quick absorption and discharge and also exchange of the solutions.

The wet treatment installation consists of prefabricated parts which are used for galvanic surface refining. As a result we obtain a robust, practical quality for the equipment which can be maintained and cared for at minimum effort. The supply of spare parts is a simple matter because of the standardized components.

The installation set up in the German Library in Leipzig comprises 6 adjacently arranged basins, measuring 50 x 70 cm with a depth of 60 cm. Above the basins there is the transport equipment which allows the transport of the containers in a horizontal and vertical direction. The basins are made of steel to which a hard rubber coating has been vulcanized. Every basin is equipped with heating, ventilation, a thermostat, in- out- and over-flow. We have attached the whole thing to the central compressed air and the hot and cold water systems of the building. The compressed air conduits permit the feeding of CO_2 directly in front of the equipment. For every 3 basins there's a control unit. Every basin has a pH level control. The level can be read off on a dial over an electrode change-over switch.

These technical provisos offer a guarantee for an accurate wet treatment, whose separate stages can be easily controlled according to individual requirements.

We are now in a position to carry out the following programme, based on already tried and tested procedures:

1. Water baths with temperatures varying between 20 - 100 c.
2. Oxydation bleaches based on Potassium permanganate.
3. Oxydation bleaches based on Hydrogen peroxide.
4. Neutralisation and establishment of an alkali reserve based on either Sodiumtetraborate, Magnesium- or Calcium-hydrocarbonate.
5. The reduction of lignin in wood pulp-based paper through the use of Peroxicarbonates and Potassium permanganate.

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6. The loosening of agglutination, mainly from starch and protein-based glues with the help of enzymes.
   As a (side effect) an optimum degree for the release of the original paper after the paper-splitting process has become possible.
7. Basic conservation of every sheet of paper through the use of p-Hydroxidiphenylmethane.
8. Adhesion of the wet-treated sheets with celluloid ethers or protein containing solutions.

The enumerated possibilities can be varied and combined in a variety of ways, so that, starting from the type of damage in question, a required and effective wet treatment combined with a high economic result can be obtained. The utilization of chemicals, the water and energy expenditure and not least of all, the problem of sewage, are all vastly improved in comparison with the manual method.

If you view all the necessary operations from the dismantling of the book to the beginning of the stabilisation process, then a thorough organisation of the work is considerably time-saving. The possibility for linking the dismantling and the dry-cleansing with the formation of various groups for damage levels and their arrangement in the support and security systems, presents a positive influence on the hygiene and microbiological situation in the workshop, along with the possibility to work in different ways with the wet treatment installation.

Endeavours towards a mechanised work procedure are being continued in the restoration workshop of the German Library. At present, we are working on the mechanisation of the paper splitting process.

A solution of the difficulty for stabilization, with the help of machines, suggests a possible linking of fundamental and expensive stages of restoration as a whole.

Before the technical solution in our case we shall, anyway, have to perform an optimal organisation of work in the existing manual process.

This procedure not only allows for an optimum technical solution, but also clarifies to a certain degree the qualitative aspect of the sought after process as we approach a technical solution.

If you will call to mind the descriptions by J. Meder from the years 1877-81, in which the splitting of paper was described in detail, and compare it with the present day practice, then further developments in this specialized area will also become clear.

Modern methods for the splitting of paper offer a rational and economic stabilisation for severe paper damage.

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The risk factors of the splitting process have been eliminated in recent years as a result of further developments. The advantage of the method lies in the numerous possibilities for variation which allows the case of damage under consideration to be stabilised in optimum form, close to the original and furthermore to treat differing categories of damage. Thus, both the stabilisation of valuable individual items, as well as the stabilisation of bulky wood-pulp-based items, can come to the fore. Stabilisation with similar materials along with an accurate wet treatment allows us to expect an increased resistance to aging and yet does not exclude renewed restoration work. At present the splitting method is applicable to all types fo paper, with the exception of coated or so-called art paper.

In order to utilize the advantages of the method to the full, a technical and basic set of equipment and an elaborate work organisation are required. In the following example the procedure for the stabilisation of wood-pulp paper by the splitting method demonstrates the present possible results. After the wet treatment with the aim of deacidification, reducing the lignin and cleansing, several hundred sheets of newspaper are prepared for splitting. The arrangement of the carrying paper can be calculated according to stock. The machanised coating of the carrying papers, the covering of the sheets of newspapers and the compression process is carried out by four workers. Thus continuous working is guaranteed.In one day several hondred sheets of newspaper can be processed. On the next day the splitting process can be carried out quickly. There are always two workers sitting opposite splitting the large sheets. The addition of the basic materials and internal adhesion is again accomplished quickly and evenly with the help of the gluing machine. As a result of the high number of items and the division of the whole procedure into sections which are easily monitored, quality and quantity can be easily altered within the physical bounds. The process of separating the carrying sheets from the leaves of paper stabilised by the splitting method has up to now consumed large quantities of energy and water. The separation process has been altered with the help of a microbic protease which is distinguishable by the absence of cellulose. The necessary amounts of energy and water can be greatly reduced.

The enzyme specifically for gelatines increases the quality as well as the aforementioned economies in the loosening phase because a risk factor is eliminated through the total removal of the film of gelatine from the original surfaces of the paper.

With the technical provisos of the mechanised wet treatment installation the cost of loosening can be greatly lowered. A hundred sheets are stacked horizontally in the transport case of the equipment between each set of filters and plastic latticing.

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For the loosening process three basins are required. In the first, there is the enzyme solution, which is kept at a constant temperature of 50° C. In the second basin, water is heated to 60° C and the third is filled with normal tap water. The pH value of the enzyme solution needs no adjustment, since its optimum pH level lies between 7 and 8. This level remains unaltered throughout the whole procedure if buffered by the addition of a magnesium calciumcarbonate solution as a binder of the internal adhesion.
The first hundred sheets are immersed in the first enzyme bath and remain there for fifteen minutes. Then they are rinsed for ten minutes in the second water bath at 60° C. Finally they are dipped briefly in the third cold water bath in order to de-activate any possible remaining enzymes.
In the transport case in between the completely gelatine-free carrying papers the newspaper sheets can be found. The second container with a further hundred sheets is immersed immediately upon release of the first one.
The carrying sheets remain attached to the original sheets after release from the transport case. Placing them alternately between filter cardboard and lightly compressing them there for ten minutes, the majority of moisture is soaked off and in the following seperation the newspaper sheets can be placed apart from the carrying sheets.
After a brief drying-off period in the air the original and carrying sheets can be pressed between cardboard and pasteboard.
This procedure does not only decrease the time expended for loosening, but also the amount of water and energy consumed. In addition,the original sheets are fastened securely between the filters for the whole loosening process. Only after most of the moisture is removed, are they mechanically loaded.
This organization for the procedure guarantees high productivity in stabilising newspaper sheets. Despite a maximum stabilisation effect and a relatively high number of sheets, the result does not yet satisfy our needs. In the present stage of development for this process, this result presents the extent of our capability. Further increases in performence can only be contemplated after extensive and thorough mechanization of parts of the process.

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Summary

Possibilities for mechanization of the restoring process. The report proves the necessity for the mechanization of restoration procedures.
To summarize examples of mechanization from Leningrad, Paris and Madrid are demonstrated and explained along with slides. Mechanized wet treatment as practised in the German Library in Leipzig, is presented in more detail. The possibilities for mechanized installations in cases of differing levels of damage are clarified both verbally and visually.

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The treatment of paper for the conservation of rare and precious books

by

Anthony G. CAINS
Director, Library Conservation Laboratory,
Trinity College Dublin

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Treatment of paper for the conservation of rare and precious books

With the great amount of library material in need of treatment relative to the resources available, we must consider carefully the time we give to the conservation and repair of each item. In the laboratory we respond to the needs of the material and our job is to do whatever is necessary as quickly and efficiently as possible. We must gauge precisily the minimum level of treatment we think appropriate for each item.

The first decision is whether the book is to be disbound or not. This is determined by the condition of the sewing; the condition of the text and the documentary value of the components. A compromise or balance has to be found in some instances, for example when the integrity, the original condition of the object is important. If the text can be satisfactorily processed without disbinding then all well and good. The choice of specification can be difficult but we have a wide range of options open to us today. We can simply postpone any extensive laboratory work by adopting a preservation treatment such as interleaving with alkaline tissue and enclosing the material in a box composed of neutral board combined with good storage and limited but careful educated use. A further stage might be gas deacidification but I know nothing about the system or how early material reacts to it.

In the laboratory we can deacidify and buffer the paper with non-aqueous systems such as methyl magnesium carbonate (R.D. Smith, Kelly et. al) and reinforce, size fragile paper and fix chalking pigment with hydroxypropylcellulose in ethanol and perform a limited range of repairs, this can, with luck, be taken to a point where a complete and adequate repair is accomplished but compared to the disbinding wet processing repair and resewing sequence may be less satisfactory and more time consumming.

The cleaning, buffering and strengthening of paper

I am concerned that the wet processing of printed and manuscript paper material be neglected in favour of the more expedient non-aqueous systems before the full potential and advantages of the method has been reached.

The product of wet processing of suitable material is generally more satisfactory than non-aqueous methods and is efficient, non-toxic and cheap.

Efficient wet processing, that is; wetting, washing, buffering and sizing will discharge and reduce staining to the point that bleaching with oxidants even if considered is found unnecessary. The amount of repair with adhesives and fine paper is reduced very considerably which means less interference with the appearance of the material and a more durable and functional product altogether.

After wet processing the paper is: flexible - requiring only light flexible repairs; tougher and chemically stable thus reducing the need for lamination or overlaid support; clean - and so no danger of disfiguring adhesive stains from the repairs; and, when applying localised reinforcement with sizing mediums no 'tide' marks are evident.

In the case of the whole book block the glue impregnating the spine folds is dissolved so that with the improved flexing and strength, the reduction in the bulk from guarding and spine margin repairs, a better book block form results.

Consequently the sewing and binding processes can be achieved with greater facility giving a more functional and durable structure.

A far greater range of problems and material types can be treated safely with aqueous solutions than is generally appreciated. This has been demonstrated by Kiko Keyes in the USA.

In our experience for an example we recently treated a modern paper manuscript displaying analine blue typescript and blue-black and red annotations. The first buffering method, tried was the magnesium methoxide sol. (R.D. Smith) and the methyl magnesium carbonate solution (Kelly). Even with the most careful minimum application the text leached and feathered. We then tried a spray application of a half saturated solution of lime water. This method was to spray both sides of the leaf and then to blot immediatly to remove any excess of the solution on the surface of the paper. The text colour and form remained unchanged and the pH of the paper stabilised at about pH 7.5 having been as low as pH 4.1 .

In a recent experiment we deacidified some sensitive image paper in our improvised humidity cabinet using a small centrifugal humidifier to dispense a mist of lime water. The result was achieved without the slightest risk to the image and so could be repeated time and again. This technique might benefit continually exhibited prints and drawings, to inhibit oxidation discoloration for example, and may suggest the basis of further development.

For the printed book that is water stained, brittle and acid nothing is better than a wash in neutral or alkaline water that is water treated with calcium hydroxide. Such material frequently resists complete wetting preventing the complete penetration of the processing solution. It is generally essential to wet the paper before washing and buffering with an appropriate mixture of water and alcohol. This has been emphasised by Margaret Hey ( ) based on our previous work at the Biblioteca Nazionale Centrale di Firenze and Trinity College.

The exception to this is when the non-wetting characteristic of the paper is exploited by the paper conservator for example when brush washing the surface of the paper to remove soil or if the image area is unstable. The correct procedure must be chosen for specific types of paper material and image mediums. Inappropriate choice of method can lead to serious physical damage and chemically inefficient processing. The equipment must be well designed and made and the laboratory layout well ordered for safe working. Practicular care should be made in the choice of wet processing supports. Much of the essential equipment can be made in the workshop, in particular the drying trays or frames and rigid support frames.

(This is in reference to simple hand methods aided by good equipment but I know of the workshop that is developing a mechanised system of wet processing - The Herzog August Bibliothek on the initiative of Dag-Ernst Petersen).

The standard technique we use I will describe under the following headings:-

Immersion in the solution

Floating on the solution

Brush application

Spray application

Immersion

The subject is totally immersed in a bath of a specific processing solution e.g. neutral water, methyl cellulose or gelatine dissolved in water. The material can be treated in block or groups of sections or folios interleaved for support with a flexible permeable non-woven polyester fabric or wet-strength paper or as single items between two such supports or with the addition of rigid supports if the subject material is fragile. The image must be stable in the solution and this must be determined before work commences. Printed books are generally processed in block. Paper documents with iron gall ink are treated individually as is printed paper in fragile and fragmented or torn condition.

A convenient portion of the interleaved book block is taken and wetted in the alcohol and water solution and placed into the deacidifying bath. This is repeated until the entire book is immersed in the bath and kept in alignment by stainless steel angle irons or beakers of solution. As the book takes up the solution, floats and swells it is gently depressed expelling the amber discoloration of the soluble degration products. This pumping action is repeated at intervals during the period of immersion until the coloured matter expelled is very faint or clear. The book block is lifted from the bath drained and lightly pressed to expel the bulk of the processing solution. The sections with their interleaves are separated and laid on net covered frames to dry, or passed through a bath of a combined size and buffer solution drained, pressed, and then dried. The washing cycle may be repeated if the paper is very discoloured.

Mould damaged and fragile printed paper must be processed leaf by leaf, using the polyester web and rigid support frames. The frames ensure safe and efficient work. Our frames are constructed from acrylic light diffusing screens covered in woven nylon gauze. The subject is placed between the polyester web and wetted with the alcohol and water applied by brush or spray. It is then placed between the frames and immersed. With the frames held firmly together a vigorous pumping action can be adopted that speeds the penetration of the water without danger to the paper. The paper is then removed from the frame supported still by the polyester web, sponged to remove excess moisture and allowed to dry.

Floating

For material with a variety of problems that preclude immersion this is the usual method of treatment. The leaf is floated on a thin film of the processing solution. The support can be a flat buoyant surface floating in a bath, such as marine plywood or acrylic rigid support buoyed with strips of expanded polystyrene.

Working on a large sheet of plate glass one can float the material on a thin film of solution applied to the surface of the glass with a sponge or brush. The subject can be brush washed to remove soil using the solution as a lubricant to avoid abrasion and to carry away the debris; if torn creased and folded it can be manipulated into correct alignment, old repairs and adhesive can be removed, if it has water soluble colour medium the penetration of the solution can be controlled with the unfixed image always at view.

Related to this procedure is 'capillary' cleaning where the processing solutions are applied from above and pass through the subject to be absorbed by a pack of absorbent material such as paper makers'felt, blotting paper, possibly aided by a vacuum table (which we do not have).

Immersion, floating and capillary vacuum processing allow you to remove degraded components and add new reinforcing stabilising components. The application of solutions by brush or spray without other aids such as the vacuum table only deposit new components.

Brush Application

To deacidify and buffer paper by non-aqueous means we generally apply methyl magnesium carbonate with a wide flat japanese brush. Brushing allows one to deposit the exact amount of solution the material will absorb without excess. With immersion one has the problem of draining the excess fluid and blotting the surface which creates problems with this unpleasant and toxic chemical (methanol). The work is always performed in a fume hood, the restricted area of which makes simple brushing more convenient. We also apply non-aqueous sizing/reinforcing mediums with a brush for similar reasons.

The spray gun.

Paper material can be wetted with alcohol/water or humidified to a specific moisture content for pressing or mounting operations but non-aqueous buffering solutions containing methanol are not sprayed. The controlled application of many aqueous sols. that can be obtained makes it a most valuable tool. The spray application of half saturated solution of lime water has proved an important method to us. Particularly sensitive, that is, water soluble areas can be masked with polyethylene or polyester film.

Sizing or reinforcing and consolidating agents can be sprayed with control of an (commercial) artists art brush, not always by direct spraying but by allowing the droplets to fall onto the surface of the object so that the image is not subject to the direct blast of air pressure.

An extension of this idea has been mentioned above that is the creation of an alkaline mist using a centrifugal humidifier. An exaporative or steam humidifier will not work because they produce only water vapour and the calcium is likely to clog the works! An indirect spray application of methyl cellulose to flaking/curling peeling thick water colour has been used at the National Gallery of Ireland by Maighread McParland with success. The methyl cellulose acted partially as a weak inert fixative and as a moisture vechicle that softens the pigment medium and allowed it to reform and reattach itself to the paper substrate aided by the gentle adhesive quality of the cellulose derivative. A point here - worth emphasing is that the application of fixatives to water soluble pigment mediums can be avoided in many cases simply by controlled hydration and subsequently storing the material at the correct RH so that its equilibrium moisture is maintained at a level to keep the system flexible. This is particularly true for illummated vellum manuscripts - and paper decorated in the same medium. The loss of tenuously attached pigment can be partly attributed to low RH and consequently low EMC. Hydration in a humidity chamber will do much to improve the binding of the pigment particles to the paper and its sizing medium, usually gelatine for early material. Such material would respond to the mist deacidification discussed above so that hydration and buffering could be combined.

During the period following the Florence flood of 4 November 1966 experiments were conducted at the BNCF by the British Rescue Fund Team (which included me) on the basis of suggestions by the late William Barrow that was to combine sizing and buffering in one operation using calcium or magnesium bicarbonate and gelatine size. The solution was not stable as had been discovered several years earlier by Sandy Cockrell at Letchworth (1962). The introduction of the cullulose derivatives in particular methyl cellulose has allowed us to produce stable solutions of various combinations.

We have also combined non-aqueous sizing and buffering mediums for example, KLUCEL G and methyl magnesium carbonate but not with consistant success. This is a valuable time saving technique particularly for printed books. Our usual aqueous preparation is a mixture of calcium hydroxide and methyl cellulose.

Fixing

The fixing of unstable image medium can extend the range of material that can be wet processed by immersion. My preference is to avoid fixatives other than our usual water soluble sizing/reinforcing medium and adopt a wet processing technique that does not endanger the image.

Fixing is done for two reasons, firstly to restablish friable and flaking pigment, and secondly to allow the paper substrate to be treated without danger of image change or loss.

The fixative medium chosen for the first purpose should be 'permanent and durable', (ie. have very good aging characteristics, be stable and inert and in no way aid decay), and not significantly change the appearance of the image. The medium chosen for the second purpose can be for permanent application or temporary support, that is the medium is applied immediately before wet processing and removed after, its purpose being to retain otherwise stable image.

Therefore in practice one may use two specific fixatives on the same image - the first a permanent one, say parchment size/ethanol to fix chalking pigment and the second, say butyl methacrylate to hold the stabilizing image during the wet processing to clean the paper base; (not necessarily in that order i.e. first temporary fix followed by permanent fix after wet processing). The methacrylate is subsequently removed by immersing the subject in acetone. A variety of mediums are available but the choice is difficult particularly in reference to mediums that are to be permanently applied. In the BNCF we used for a time soluble nylon in methanol for both fixing unstable watercolours in books and to allow the washing necessitated by the presence of mud. The nylon is not easily or conveniently removed and presented many technical and aesthetic problems.

I would support the use of aqueous mediums (that are not cross-linked that is rendered irreversibly insoluble) such as gelatine or methyl cellulose and hydroxypropylcellulose as fixatives or pigment and paper consolidants.

For temporary fixing the localised application of paraffin wax in petroleum ether 5-10% w/v is of value - and butyl or methylmethacrylate with acetone as the solvent. All published methods. The paraffin wax is easily dissolved in petroleum ether but several immersions in such solvent may be necessary to clear the wax completely so that costs may be high. There are so many variables that the conservator is advised to experiment with solution viscosities, method of application and removal for each type of problem until a method is found that can be trusted for the specific problem.

Repair

Our methods of repair are conventional and our need for fibre-casting capability minimal, so that the simple hand methods of Willy Thamm et al are sufficient for our needs. Our 'speciality' is the manufacture of our own heat-set repair tissue which I have been manufacturing and improving since 1962 (Morris, Cockerell, Waters, Powell, Nkrumah, Hey, et al). The advantage of preparing the tissue in the laboratory is that its composition can be altered at will to suit the needs of specific problems. We can vary the gauge of the adhesive, its composition and the tone and colour of the tissue. Margaret Hey, who worked with me, Joe Nkrumah and Peter Waters on the development of this material for the BNCF has recently submitted samples for me to test, of a commercially made tissue very similar to the product but as yet inferior in many respects to our 'home made' material. Using extremely thin films of acrylic resin the tissue is easily removed in acetone ethanol and even water. Infilling missing areas, repairing folds are usually performed using Japanese hand-made papers and starch paste. Our methods are published in the Paper Conservator - the Journal of the Institute of Paper Conservation under the authorship of Matthew Hatton, Orla McMullen and myself and further material in the New Bookbinder and the post-prints of Cambridge 1980 to be published by Butterworths.

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